LTH
Electronics

Application Note

Best Practice for Calibrating LTH Conductivity Instruments

As accurate process measurement becomes an everyday requirement it is vital to be able to calibrate conductivity instruments and systems. This application note details the best practice for this operation and gives practical guidelines as to methods and equipment.

LTH Electronics can supply their conductivity instrumentation and sensors with calibration certificates traceable to National Standards. Clear and concise calibration certificates are e-mailed to customers on the date of despatch of their orders.
The calibration certificates detail the customer name and address, order reference, the LTH works order number, date of calibration, next calibration due date, details of the calibration equipment used and the standards to which the work refers to.
Most LTH Instruments provides a facility for the operator to fine-tune the calibration of the conductivity or resistivity measurement, the temperature measurement and the current output (s). The amount of adjustment is quite small as factory calibration is accurate and with modern electronics, drift is very low.
If it is found that during a calibration there is insufficient adjustment then it is probable that there is a problem with either the calibration procedure, or a fault with the instrument, sensor or cabling. The most common causes of inaccurate conductivity readings are contaminated electrode surfaces and air trapped within the cell.
Both of these will always give a low conductivity or high resistivity reading.
Conductivity cells should always be installed in accordance with the manufacturer's instructions. Contacting conductivity cells will require periodical inspection and cleaning depending on the process they are used in.

LTH Electrodeless or Inductive conductivity sensors contain two toroidally wound coils encapsulated with screening to form a sensor. When the sensor is immersed in the solution to be measured a conductive loop is created through the sensor. A high frequency alternating current is applied to one of the coils which induces a current in the conductive loop. The second coil senses the magnitude which is directly proportional to the conductivity of the solution. Electrodeless or Inductive sensors have been developed to overcome the problems of electrode blinding or fouling and will require virtually no maintenance.

Calibration of Conductivity or Resistivity Readings

Conductivity measurements are very temperature dependent, so it is essential that an understanding of the complex relationship between conductivity and temperature is understood when calibrations are made. It is possible to make several different types of calibration.

Resistance Calibration of the Conductivity Instrument only

This is the most accurate method of calibrating the instrument but it will not take into account any inaccuracies due to cell constant variation or coatings of contaminants. Calibration is at a single point only so a value close to the normal operating conditions is preferable. Firstly disconnect the existing conductivity cell and connect a resistance decade box between the C and E terminals. (See the table of values at the end of this Application Note).
It is recommended that any extended lengths of cell cable be left in during this calibration, as cable resistance will have some effect on the overall calibration accuracy. This is increasingly significant at high values of conductivity or low resistivity.
The temperature compensation must be switched out when making these adjustments and the relevant cell constant noted. The resistance accuracy will determine the overall accuracy of the calibration. A non-inductive resistance must be used below 100 ohms. A table of values for specific calibration points is given in the equipment manual.

This method is not suitable for Electrodeless conductivity systems. These systems will need to be tested as a “loop”. Refer to the appropriate instrument instructions for performing a Zero calibration, then connect the required calibration resistor through the Electrodeless conductivity sensor and complete the loop calibration.
LTH can supply a set of calibration resistor loops for their Electrodeless conductivity systems.

Calibration with Standard Solutions

This calibration must be carried out under strictly controlled conditions due to the temperature effect on conductivity measurements and the possibility of contamination of the standard solution. The advantage of this calibration method is that the sensor and cable are an integral part of the calibration. Care must be taken when using standard solutions as conductivity is a very sensitive measurement and even trace contamination of the standard solution will be detected, for example exposing the solution to air will add 1µS/cm to the standard solution due to absorption of CO2 .
Most standards are made up from a solution of KCl dissolved in high purity water.
EN 60746-2:2003 provides details of the concentrations of KCl necessary to produce industry standard conductivity solutions.
LTH Electronics can supply a range of aqueous non hazardous ready-made standard solutions to suit different applications with traceable certification.
Standard solutions will be supplied with a conductivity value quoted at a reference temperature and an expiry date. The temperature is the base temperature and the calibration should be performed at this temperature, with the temperature compensation switched out. Alternatively, the temperature compensation should be switched on and a temperature slope and base temperature equal to that of the calibration solution can be used to configure the instrument. For example this would be 1.76%/°C for a KCl solution between 1000 to 10,000µS/cm. For more details on calculating the slope of a different solution, refer to the end of this Application Note.

When using an Electrodeless conductivity sensor it is essential that the sensor does not rested on the bottom or side of the beaker or test vessel. The face of an Electrodeless conductivity sensor should be 25mm from another surface.

Calibration by Comparison with Another Instrument

This can provide the easiest method for in-situ calibrations but does have the disadvantage of only being able to check a single measurement point.
LTH Electronics recommends this method for ALL pure water (<10 µS/cm) calibration checks and has developed the AquaCal 2000 portable pure water measurement kit specifically for measuring the conductivity or resistivity of pure water to traceable standards and can be used to validate pure water treatment plants.
As measurements are made by comparison of the readings taken in the same solution, temperature effects are less critical. However, it is essential that settings for temperature compensation are the same on both instruments.
For more information on the measurement of pure water refer to Appendix C of the MCD53 manual, HCT63 manual or to the AquaCal 2000 manual.
For conductivities above 100 µS/cm LTH can offer the HD2306.0 portable conductivity meter which is suitable for use in industrial applications and laboratories and is ideal for service engineers.

Calibration of the Cell Constant

LTH contacting conductivity cells are supplied with a nominal cell constant value, e.g. 0.01, 0.1, 1.0. and 10.0. The actual cell constant could be up to ±2% from this value.
It is possible for LTH to measure the actual cell constant of each cell and provide traceable certification.
A copy of the calibration certified cell constant is e-mailed to the customer.
The calibration certificates detail the customer name and address, order reference, the LTH works order number, date of calibration, and next calibration due date, details of the calibration equipment used and the standards to which the work refers to.
To help the customer we offer a calibration reminder service notifying you by e-mail.
For the MCD53 and HCT63 range of instruments, the user can then program the exact cell constant value into the instrument, eliminating the errors contributed by manufacturing variations in the cell geometry. For other instruments, refer to the appropriate handbook for details.

LTH Electrodeless conductivity sensors are supplied with a fixed cell constant and will not require an adjustment. However an Electrodeless conductivity system will require calibration using the correct loop resistor.

Care and Maintenance of Conductivity Sensors

Conductivity measuring systems are designed to be trouble free in use and reliable measurements can be expected during their operating life. However, some maintenance is required. In particular, the cell and cable connections should be checked for security and freedom from corrosion.
Contacting conductivity sensors will also require periodic cleaning, depending on the quality of the water passing through it and the type of sensor employed. A dirty cell will always give a low conductivity reading.
The area of the cell which is sensitive to fouling is the electrode surfaces which must fully "wet" to ensure accurate measurements. Moulded cells are often used in applications where a high level of contamination may be expected.
Some of these contaminants do not contribute directly to the measured conductivity, e.g. organics, rust and suspended solids, but may form deposits on the electrode surface. In general these may be cleaned with the bristle brush provided and a weak detergent solution mixed with scouring powder.

Problems may occur in hard water areas where the gradual formation of scale will reduce the active area of the electrodes. Simple brush cleaning alone will not remove a hard deposit from the electrode surface. If scaling is suspected the cell should be removed from the system and treated with a 10% solution of hydrochloric or formic acid. The presence of bubbles will indicate that scale is being dissolved. Cleaning is completed when bubbles cease and usually takes 2-3 minutes. The cell must be thoroughly rinsed to remove all traces of acid before it is replaced in the system.

Note: Follow the supplier's data sheet when handling acids and dispose of as instructed by your local authority regulations.

Cells with stainless steel electrodes are generally used in applications where a low conductivity is combined with a low level of organic contamination and cleaning is rarely necessary. Errors in measurements can often be traced to faulty connections or incorrect setting on the instruments. However if contamination is suspected the cell should be removed from the system and cleaned if necessary.
Handling of the cell electrodes will leave residues of oils and greases which will affect the wetting of the surfaces, leading to inaccurate readings. After touching the electrodes, wash them with a weak detergent solution and rinse thoroughly.
After rinsing check that the surfaces 'wet' properly, that is, they maintain a complete film of water for approximately 10 seconds.

Electrodeless conductivity sensors will require very little or no maintenance as their measuring parts are not in direct contact with the process solutions being measured. The only time a problem could arise is if the centre sensor hole becomes blocked

Calculating the Temperature Coefficient of a Solution

If the temperature coefficient of the solution being monitored is not known, the conductivity instrument can be used to determine that coefficient. You should set the instrument to a suitable range and either the temperature coefficient to 0.0% or the temperature compensation off.
The following measurements should be made as near to the normal operating point as practical, between 5°C and 70°C for the highest accuracy. Immerse the measuring cell in at least 500 ml of the solution to be evaluated, allow sufficient time to stabilize approximately one or two minutes, agitate and stir to ensure removal of all air bubbles, and then record both the temperature and conductivity readings.
Raise the solution temperature by at least 10°C and again record the temperature and conductivity readings.
Using the following equation, the temperature compensation slope can be calculated in percentage terms:

$$\alpha = \frac{(Gx-Gy) \times 100\%}{Gy(Tx-25) - Gx(Ty-25)} \quad \text{(base temperature 25°C)}$$

Note: If base temperature is set to 20°C, then replace 25 with 20 in the above equation.

Term	Description
Gx	Conductivity in µS/cm at temperature Tx
Gy	Conductivity in µS/cm at temperature Ty

Note: One of these measurements can be made at ambient temperature.

Set the temperature compensation slope to the calculated value. The temperature compensation is now set up for normal operation.
If it is difficult or impossible to evaluate the temperature compensation slope using this method, a 2.0 % / °C setting will generally give a good first approximation until the true value can be determined by independent means.

Table of Contacting Conductivity calibration resistance values

Conductivity Display Reading	Nominal cell constant K=0.01	Nominal cell constant K=0.1	Nominal cell constant K=1.0	Nominal cell constant K=10.0	Resistivity Display reading
0.050 µS/cm	200K				20.00 MΩ-cm
0.100 µS/cm	100K				10.00 MΩ-cm
0.200 µS/cm	50K				5.00 MΩ-cm
0.500 µS/cm	20K				2.00 MΩ-cm
1.000 µS/cm	10K	100K			1.00 MΩ-cm
2.000 µS/cm	5K	50K			500 KΩ-cm
5.000 µS/cm	2K	20K			200 KΩ-cm
10.00 µS/cm	1K	10K	100K		100 KΩ-cm
20.00 µS/cm	500R	5K	50K		50.00 KΩ-cm
50.00 µS/cm	200R	2K	20K		20.00 KΩ-cm
100.0 µS/cm	100R	1K	10K	100K	10.00 KΩ-cm
200.0 µS/cm		500R	5K	50K	
500.0 µS/cm		200R	2K	20K	
1000 µS/cm		100R	1K	10K	
2.000 mS/cm			500R	5K	
5.000 mS/cm			200R	2K	
10.00 mS/cm			100R	1K	
20.00 mS/cm			50R	500R	
50.00 mS/cm			20R	200R	
100.0 mS/cm			10R	100R	
200.0 mS/cm				50R	
500.0 mS/cm				20R	
1000 mS/cm				10R	

This list of calibration resistance values will allow the user to check or modify the calibration of the instrument. Temperature compensation MUST be turned off during the test or adjustment.